Machines, the Military, and Strategic Thought

Colonel Antonio M. Lopez, Jr., U.S. Army, Retired, Ph.D.; Colonel Jerome J. Comello, U.S. Army, Retired, Ph.D.; and Lieutenant Colonel William H. Cleckner, U.S. Army, Retired

We have to think differently. The enemy who appeared on September 11th seeks to evade our strength and constantly searches for our weaknesses. So America is required once again to change the way our military thinks and fights.

-President George W. Bush¹

ISTORICALLY, real-world events trigger innovative thought, as for example, the challenge from President John F. Kennedy to land men on the moon and return them safely to earth by the end of the 1960s. The more dramatic the event, the more we recognize the need for thinking differently. History shows, however, that nondramatic advances in technology often produce innovations in thought we do not recognize until some dramatic human tragedy catapults the innovative thinking into the spotlight.

The U.S. Army must continue to change the way it thinks. In today's world, information is multiplying even as it is becoming obsolete, and ideas are continually restructured, retested, and rethought. The Army cannot survive if it uses only one way of thinking; it must continually adapt to match the thinking of opposing forces, enhance its strategic thinking, make better use of current technologies, and take advantage of near-future technologies.

Intelligent-agent technology, which stems from research in artificial intelligence (AI), has advanced significantly since the late 1980s. An intelligent agent is a computer program that perceives its environment, reasons about it, then acts on it as would a human subject matter expert (SME).² The Persian Gulf war accelerated the U.S. military's use of intelligent-agent technology in operational de-

cisionmaking.³ The Semantic Web will be another step forward in the military use of intelligent-agent technology.⁴

The Semantic Web is the envisioned end state for the movement of the World Wide Web from words, images, and audio understood only by humans to the same data "wrapped in" organizing concepts and relationships that intelligent agents as well as humans can understand.⁵ In the not too distant future, intelligent-agent technology and military thinking will combine to use the Semantic Web to understand the strategic contexts of situations based on knowledge and inference.⁶

As we wage the Global War on Terrorism (GWOT), we must rethink old concepts. Humans and intelligent agents together will have to learn new concepts. In the words of author Peter Paret, "Each age has its own strategy. The strategies of 1806, of 1870, of 1914 were the products of their own times, certainly paying some attention to history, but primarily attempting with varying degrees of success to use and respond to the economic, social, technological, and political conditions of their day." Our age is now. How should we think differently about strategy?

Machine Thinking

Artificial intelligence is approaching adolescence. Its childhood years were filled with "wide-eyed dreaming and wild speculation." Some early AI consumers believed childish promises about AI and were quite disappointed when it failed to deliver. Many still remember the experience and say, "AI. Wasn't that the thing we talked about a decade ago, and didn't it fail?" Far from being a failure, AI has

become strategically important to the military and to corporate America in the search for advantages over adversaries.

The Dynamic Analysis and Replanning Tool (DART) is an AI-based decision-support system installed at the U.S. Transportation Command

and U.S. European Command within 3 months of its conception and used throughout the Persian Gulf war. DART solved the logistical nightmare of moving military assets from Europe to Saudi Arabia. The money DART saved reportedly offset all funds the Defense Advanced Research Projects Agency (DARPA) had funneled into AI research in the previous 30 years. 10

After the Persian Gulf war, AI researchers developed intelligent systems to capture lessons learned through firsthand human experience. One such deployed system is the U.S. Air Force's Air Campaign Plan-

ning Advisor, which is a Web-based system linked to a performance support system.¹¹

DARPA, whose focus is on areas in which AI techniques help obtain reasonable solutions to complicated, real-world military problems, has supported development of intelligent-agent technology through several of its programs. DARPA, the Air Force Office of Scientific Research (AFOSR), and the Air Force Research Laboratory of the Air Force Materiel Command supported the Learning Agent Laboratory (LALAB) at George Mason University in developing "Disciple"—a theory, methodology, and intelligent-agent shell SMEs can use to rapidly develop knowledge bases in specific domains. The SMEs required only limited assistance from computer professionals specializing in knowledge engineering.

The Disciple approach successfully solved "challenge problems" in DARPA's High Performance Knowledge Bases program. ¹² DARPA's follow-on program, Rapid Knowledge Formation (RKF), addressed a decades-old bottleneck caused by the need for SMEs to repeatedly explain problem-solving techniques to knowledge engineers who, in turn, encoded them for validation

and future use by subject matter experts.

DARPA and AFOSR supported the development of Disciple-RKF and approved the domain of application—determining and analyzing an opposing force's center of gravity (COG). Prussian strategist Carl von Clausewitz described the COG as "the hub

> of all power and movement, on which everything depends."¹³ Today, the Army defines the COG as "those characteristics, capabilities, or localities from which a military force derives its freedom of action, physical strength, or will to fight."¹⁴

In 2000, LALAB joined forces with the Center for Strategic Leadership at the U.S. Army War College (AWC) to conduct AI research and COG analysis and to use intelligent agents in education. ¹⁵ The team used a COG monograph to develop a knowledge-intensive COG analysis problem. ¹⁶ Students studying the COG concept in depth could

COG concept in depth could take an elective course titled Case Studies in Center of Gravity Determination. Students used Disciple-RKF/COG to elicit scenarios and model military campaigns. Students in the Military Applications of Artificial Intelligence (MAAI) course completed the training of Disciple-RKF/COG agents. After 2 years of development and refinement, Disciple-RKF/COG became part of AWC's COG and MAAI elective courses.¹⁷

To make web content more accessible and understandable to intelligent agents, DARPA funded research in languages, tools, infrastructure, and applications. The DARPA Markup Language (DAML) is the language autonomous intelligent agents use to understand Semantic Web pages. The Department of Defense (DOD) and intelligence communities are pushing for computer systems based on Semantic Web principles. 19

Ontologies are the key to the Semantic Web because they promise a shared understanding of a domain that can be communicated between people and intelligent agents.²⁰ An ontology is a logical theory that gives an explicit, partial account of a conceptualization; it is an intentional semantic structure that encodes the implicit rules that



Carl von Clausewitz

constrain the structure of a piece of reality.²¹

Developing an ontology for Disciple-RKF/COG was essential, but that ontology was based on historical case studies with state actors and militaries, governments, alliances, and coalitions with hierarchical structures.²² On a Semantic Web scale, people

around the world will develop and use ontologies to convey the meaning of their web pages. The real power of ontologies will be realized when people create intelligent agents that use ontologies to collect web content, process the information, and exchange the results with other intelligent agents and humans.²³

Artificial intelligence is coming of age. Soon, we might see the Semantic Web and intelligent-agent technology enhance our ability to respond to economic, social, technological, and political conditions. Is the military prepared to use

such tools to think differently? Adapting such tools into our thinking process will improve the correct, timely identification of the strategic COG (SCOG).

Military Thinking

Since its inception, the AWC has put a premium on thinking and innovation and promoted the use of technology, even experimental technology, so its students and future military and civilian leaders could better inform themselves about how new technology will affect them. One of the more difficult challenges military and civilian leaders face at the strategic level of war is to determine and analyze the SCOG for friendly and enemy forces. The trouble begins with the overused word "strategy." The DOD Dictionary of Military and Associated Terms defines national strategy, military strategy, national military strategy, and theater strategy.²⁴ There is even a distinction between grand strategy, which has a practical level of influence on the "economy, industrial structure, demography, sociology, strategic [sic], and culture," and strategy, which has a practical level of influence with "services, army groups, fleets," and so on.²⁵ In some circles, the word strategy has become synonymous with foreign policy. 26 Furthermore, what is called national strategy in the Pentagon and what many historians and theorists call grand strategy overlap policy. Distinguishing between and among the three concepts is difficult.²⁷ To do so, Columbia University professor Richard Betts suggests that the military think of strategy as the bridge between policy and operations.²⁸ This be-

ing the case, determining the SCOG requires knowledge from the military domain (operations) and from the economic, political, psychosocial, historic, and international domains (policy).

SCOG analysis is quite scenario-dependent because it deals with specific adversaries and their goals and capabilities. When performing SCOG analysis, senior military officers rely on their experience and intuitions, usually without following a rigorous analytical methodology or reflecting thoughtfully on Clausewitz. In the GWOT, however, a new dimension of difficulty is



Napoleon Bonaparte

added, one in which the experience and intuition of military leaders is deficient.

Instead of state actors with military components organized hierarchically, the U.S. military must confront nonstate opponents who have no traditional military units and are part of a global network that can easily include or exclude other organizations. The military assumption that an opposing force will have central control over its components clashes with the reality that globally coherent activity can emerge in the absence of centralized authority or control.²⁹

Disciple-RKF/COG has been an unquestionable success, but SMEs and knowledge engineers working at the AWC recognized the need for its further development before the tragic events of 11 September 2001. In summer 2001, they examined events that occurred in Somalia from 1992 to 1994 in terms of strategic and operational COG concepts.³⁰ In their scenario, Somalia was not a state, but a geographical area in which many different clans operated independently, often in open conflict with each other. The clans, operating in more of a network than a hierarchical structure, came together for a common purpose and cut off ties completely when the purpose no longer existed. The on-again, off-again UN operations in Somalia from December 1992 to

May 1993 demonstrated the complexity of the situation and the UN's sluggishness in developing a viable plan of action. U.S. frustration with UN inaction led to a more direct U.S. role, which culminated in the Unified Task Force. Unknown then, the stage was being set for the paradigm shift to today's Global War on Terrorism.

Strategic Thinking and the Three-Step Program

Throughout history, the military has built and used machines to gain operational or tactical advantage over opponents. Recently, the military has used computers in smart weaponry and battlefield digitization. The military can now think differently by adapting intelligent-agent technology to support military thinking at a much higher level of thought than ensuring bombs are on target or knowing unit battlefield locations.

The United States must combine intelligent-agent technology and the looming Semantic Web to gain strategic advantage over opponents such as al-Qaeda. Paret prophetically pointed out, "Often—as in significant phases of the First World War—a strategy lags behind contemporary reality. Napoleon, by contrast, developed strategies that were attuned to the possibilities of his age, and for some years succeeded in exploiting them fully. As the conditions that he understood and had mastered began to change, sometimes in response to his own actions, his strategic concept, too, had to change or become outdated."31 As Napoleon changed his strategic concepts based on changing conditions, we must change based on the contemporary realities of our ageintelligent-agent technology, networked nonstate enemies, and a Semantic Web that both humans and machines will understand. Can we develop a strategy that fully exploits these realities?

To support change in strategic thinking, we offer a three-step program to exploit current technologies and to position us to further exploit nearfuture technologies. The first step is to get a clear understanding of the concepts and their relationships. Clausewitz laid the foundation for this step when he wrote that the cognitive function of theory is to structure

past and present realities to show "how one thing is related to another; [to] keep the important and unimportant separate; to reach the irreducible elements of the phenomenon of war; and to discover the logical and dynamic links that bind them into comprehensible structure."³² An ontology used by intelligent agents explicitly represents these concepts and their relationships, and the Semantic Web will help separate important concepts from unimportant ones. The intelligent agent determines logical, dynamic links that bind concepts into a comprehensible structure.

Clausewitz's dictum that "war is nothing but the continuation of policy with other means" illustrates the first step in our program.³³ Published on the Semantic Web, Clausewitz's work might have the ontological representation found in figure 1(a), but written in DAML. Assuming that Betts's paper, expressing the view that strategy is the bridge between policy and operations, was also published on the Semantic Web using DAML with an ontological representation such as that in figure 1(b), then an intelligent agent would conclude that Betts's writing is consistent with Clausewitz's dictum.

The intelligent agent would understand that Betts added more explicit concepts and relationships to Clausewitz's concepts of policy and war. On the Semantic Web, the posted writings that disagree with Clausewitz's dictum could be separated out. The intelligent agent could also follow hyperlinks to the papers Betts referenced and to papers written by others who referenced Betts's paper. Unlike today's web crawlers and search engines that use keywords to determine patterns, the intelligent agent on the Semantic Web would use ontological representations written in DAML to understand a document's content.

The second step is to use intelligent-agent technology to enhance thinking. For an intelligent agent

to do its work (that is, understand its environment, reason [think], and take action based on its understanding and reasoning), it must have an ontology, a theory that allows humans to share knowledge with machines and vice versa.

Having military minds build ontologies for GWOT is true to Clausewitz's view of theory's pedagogic function to

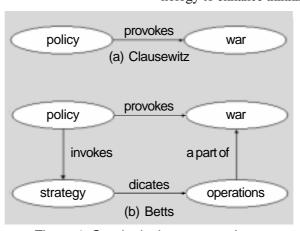


Figure 1. Ontological representations.

MENTAL PREPAREDNESS

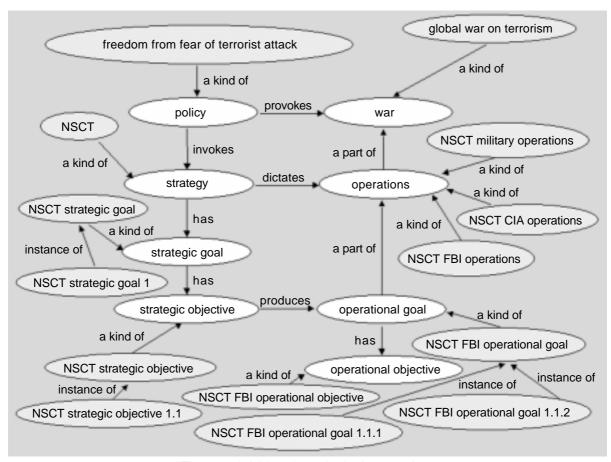


Figure 2. Additional ontological expansion. (Shaded areas are present-age concepts).

"help the student organize and develop his ideas of war, which he draws from experience, study, and history [so] the exploration of the past extends the reality that any one individual can experience." Experience and the past are important, but the need to understand more precisely how economic, religious, and ideological factors affect war is becoming just as important.

When conditions Napoleon understood and had mastered began to change, he had to change his strategic concepts. When a network of terrorist organizations and cells confronts the United States, how does the military organize and develop new ideas? Consider the National Strategy for Combating Terrorism (NSCT).³⁵ U.S. policy is for its citizens and other civilized people around the world to lead lives free of fear from terrorist attacks. Based on this policy, the NSCT presents several strategic goals, each having its own objectives. For example, the objectives of goal 1—to defeat terrorists and their organizations—might include the following:

Objective 1.1. Identify terrorists and terrorist organizations.

Objective 1.2. Locate terrorists and their organizations.

Objective 1.3. Destroy terrorists and their organizations.³⁶

Can the ontological representations in figure 1 incorporate the reasoning expressed here? We believe they can and that they can help the military organize and develop ideas about this type of war.

Expansion of the previous ontological representation is possible at a higher level of abstraction. An intelligent agent could read the NSCT on the Semantic Web and begin to understand the specifics of the strategy (the what) but would have to look elsewhere on the web for operations (the how).

Suppose the FBI, the CIA, and other government agencies create Semantic Web pages that present their goals for conducting the GWOT. For example, the FBI identifies terrorist cells and organizations operating within U.S. borders, and the CIA identifies them outside U.S. borders. If it knows the strategy,

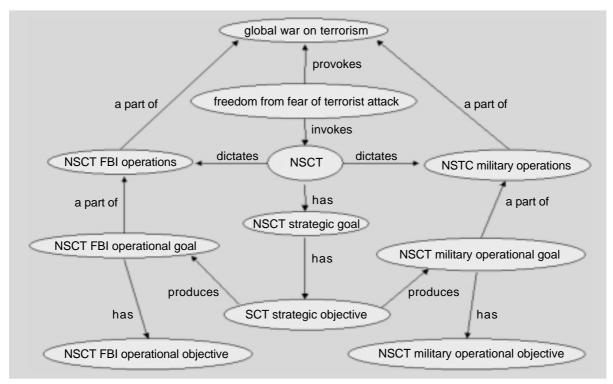


Figure 3. Machine and military thinking combining into strategic thinking.

the intelligent agent can link operational goals to strategic objectives. Expanding the enumeration system results in the following:

Operational goal 1.1.1. The FBI will identify terrorist cells within U.S. borders.

Operational goal 1.1.2. The FBI will identify terrorist organizations within U.S. borders.

Operational goal 1.1.3. The CIA will identify terrorist cells outside U.S. borders.

Operational goal 1.1.4. The CIA will identify terrorist organizations outside U.S. borders.

Now, the intelligent agent can search for the operational objectives for each of the operational goals.

Figure 2 depicts higher-level concepts and adds war, policy, strategy, operations, and a good deal more. The concepts in gray are those the military strategist provided in an ontology of war. An intelligent agent can use the ontology and the Semantic Web to find the shaded concepts for a specific war. This synergy of military and machine thinking produces a better understanding for both humans and machines.

Figure 3 offers a view of the GWOT without its theoretical underpinning (the concepts in gray in figure 2). Lest we forget, Clausewitz would remind us: "Theory can never lead to complete understanding, which is an impossibility, but it can strengthen and refine judgment."³⁷

The final step is to use military and machine thinking to gain a comprehensive understanding of war. Clausewitz admonished, "Theory must be comprehensive; that is, it must be able to accommodate all aspects of its subject, whether of the present or of other times. It must be based on the constants and absolutes of its subject, not phenomena that might be temporary, even if currently these phenomena seem to dominate war." ³⁸

We have worked with the COG theory as it applies to war between states even when they are part of coalitions or alliances. Identifying and determining the SCOG in these cases has focused on the Clausewitzian trinity of government, military, and people. The current phenomenon is war with a nonstate opponent organized in a decentralized network, however. In this phenomenon, the SCOG still exists, but government and a military organization are no longer critical to its identification. We believe the COG theory must be extended by adding goals and objectives to the constants and absolutes of war in a way similar to Betts's extension of Clausewitz's dicta.

In time, the Semantic Web will enhance understanding of the world. Intelligent agents will use it to read documents, filter information, and infer knowledge faster than humans can. As Clausewitz wrote, "If war was meant to achieve a political pur-

MENTAL PREPAREDNESS

pose, everything that entered into war—social and economic preparation, strategic planning, the conduct of operations, the use of violence on all levels should be determined by this purpose, or at least in accord with it."39

Thinking differently does not begin with an intelligent agent; it begins with the agent's intelligent partner—the SME who sees into the future and develops the needed ontologies. The military needs a new model to update and expand Clausewitz's COG theory at the strategic level. The model should use existing intelligent-agent technology and prepare for the future use of the Semantic Web.

Creating new ontologies, if nothing else, will help clarify military thinking. Furthermore, we can use such ontologies to expand the understanding of agents such as Disciple-RKF/COG. Having an intelligent agent with knowledge of the COG theory and traditional warfare is a significant advantage. As different military thought patterns evolve for a new, global, networked model, they can be tried on the intelligent agent and reviewed to see which are helpful in finding the SCOG for the new environment. MR

NOTES

- 1. George W. Bush, speech at The Citadel, Charleston, South Carolina, 11 December 2001.
- 2. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (Upper Saddle River, NJ: Prentice Hall, 1995).

 3. William Owens, Lifting the Fog of War (New York: Farrar, Straus, Giroux, 2000).
- 4. Henry S. Kenyon, "Computer Language Seeks Deeper Meaning," Signal (June
- Tim Berners-Lee, James Hendler, and Ora Lassila, "The Semantic Web," Scientific American (May 2001): 34-43.
 Otis Port, "The Next Web: Think the World Wide Web is a Godsend? By 2005,
- Tim Berners-Lee aims to be replacing it with the Semantic Web, which will understand human language," *Business Week*, 4 March 2002, 96-102.

 7. Peter Paret, *Makers of Modern Strategy: From Machiavelli to the Nuclear Age*

- (New Jersey: Princeton University Press, 1986), 141.

 8. James Allen, "Al Growing Up," *Al Magazine* (Winter 1998): 13-23.

 9. Frederick Hayes-Roth, "Artificial Intelligence: What Works and What Doesn't?" Al Magazine (Summer 1997): 99-113.
- 10. Sarah Reese Hedberg, "DART: Revolutionizing Logistics Planning," IEEE Intelligent Systems (May-June 2002): 81-83.
 11. Christopher R. Johnson, Larry Birnbaum, Ray Bareiss, and Tom Hinrichs, "War
- Stories: Harnessing Organizational Memories to Support Task Performance," *Intelligence* (April 2000): 17-31.
- 12. Gheorghe Tecuci, Mihai Boicu, Michael Bowman, and Dorin Marcu, "An Innovative Application from the DARPA Knowledge Bases Programs: Rapid Development of a High Performance Knowledge Base for Course of Action Critiquing," Al Magazine (March 2001): 43-61
- 13. Carl von Clausewitz, On War, trans. and ed. Michael Howard and Peter Paret (New Jersey: Princeton University Press, 1976), 595.

 14. U.S. Army Field Manual 3-0, *Operations* (Washington, DC: U.S. Government Print-
- ing Office [GPO], 2001). 15. Antonio M. Lopez, Jr.; Jerome J. Comello; Michael Bowman; James J. Donlon;
- and Gheorgh Tecuci, "Clausewitz Meets Learning Agent Technology," *Military Review* (November-December 2002): 10-17.
- 16. P.K. Giles and T.R. Calvin, Center of Gravity: Determination, Analysis, and Application (Carlisle Barracks, PA: U.S. Army Center for Strategic Leadership, 1996, updated
- 17. Gheorghe Tecuci; Mihai Boicu; Dorin Marcu; Bogdan Stanescu; Cristina Boicu; Jerome J. Comello; Antonio M. Lopez, Jr.; James J. Donlon; and William Cleckner, "Development and Deployment of a Disciple Agent for Center of Gravity Analysis," Proceedings of the Eighteenth National Conference on Artificial Intelligence and the Fourteenth Conference on Innovative Applications of Artificial Intelligence, Menlo Park, CA, AAAI

- 18. Deborah L. McGuinness, Richard Fikes, James Hendler, and Lynn Andrea Stein "DAML + OIL: An Ontology Language for the Semantic Web," IEEE Intelligent Systems (September-October 2002): 72-80.
- Kenyon, 60.
 John Davis, Dieter Fensel, and Frank van Harmelen, Towards the Semantic Web: Ontology-Driven Knowledge Management (West Sussex, UK: John Wiley & Sons, 2003). 21. Nicola Guarino and Pierdaniele Giaretta, "Ontologies and Knowledge Bases: To-
- wards a Terminological Clarification," in Towards Very Large Knowledge Bases: Knowledge Building and Knowledge Sharing, ed. N.J.I. Mars (Amsterdam: ISO Press, 1995),
- 22. Michael Bowman; Antonio M. Lopez, Jr.; and Gheorghe Tecuci, "Ontology Development for Military Applications," Proceedings of the Thirty-Ninth Annual ACM Southeast Conference, New York, ACM Press, 2001, 112-17.
- 23. Benners-Lee, 42.
 24. Joint Chiefs of Staff, Joint Publication 1-02, DOD Dictionary of Military and Associated Terms (Washington DC: GPO, 12 April 2001), on-line at <www.dtic.mil/ doctrine/iel/doddict>
- 25. Ian Roxborough, "From Revolution to Transformation: The State of the Field," Joint Forces Quarterly 32 (2002): 68-75.
 26. Richard K. Betts, "The Trouble with Strategy: Bridging Policy and Operations,"
- Joint Forces Quarterly 29 (2002): 23-30. 27. Ibid., 24.
- 28. Ibid.
- 29. Duncan J. Watts, Six Degrees: The Science of a Connected Age (New York: W.W. Norton & Company, 2003), 51.

 30. Christopher Fowler: William Cleckner: Antonio M. Lopez, Jr.: Gheorahe Tecuci:
- and Jerome Comello, "Strategic Center of Gravity Analysis for Operations Other Than War Through Learning Agent Technologies," Proceedings from the Forty-First Meeting of the Army Operations Research Society, 2002, CD-ROM: Special Session 2, The Application of Information Technology on the Battlefield, Fort Lee, Virginia, Center for Army Analysis, U.S. Army Logistics Management College, 2002.
- 31. Paret, 141. 32. Ibid., 193.
- 33. Clausewitz, 69 34. Paret, 193.
- 35. The White House, National Strategy for Combating Terrorism (Washington, DC: 2003), on-line at <www.whitehouse.gov/news/releases/2003/02/counter_terrorism/ counter_terrorism_ strategy.pdf>, accessed 16 July 2004.
- 36. Ibid., 15-16. 37. Paret, 193.
- 38 Ibid
- 39. Clausewitz, 6.

Colonel Antonio M. Lopez, Jr., U.S. Army Reserve, Retired, Ph.D., holds the Conrad N. Hilton Endowed Chair in computer science at Xavier University of Louisiana. He received a B.S. from Loyola University, an M.S. and a Ph.D. from Clemson University, and he is a graduate of the U.S. Army Command and General Staff College (CGSC). He has served in various positions in the continental United States (CO-NUS), Kuwait, and Qatar.

Colonel Jerome J. Comello, U.S. Army, Retired, Ph.D., is a professor of military studies at the U.S. Army War College (AWC). He received a B.S. from the U.S. Military Academy (USMA), an M.S. from George Washington University, and a Ph.D. from Temple University. He is a graduate of the College of Naval Command and Staff and the National War College. He has served in various positions in CONUS, Vietnam, and Germany.

Lieutenant Colonel William H. Cleckner, U.S. Army, Retired, is a professor of operational research at the AWC. He received a B.S. from the USMA, an M.S. from the Naval Postgraduate School, and he is a graduate of CGSC. He has served in various positions in CONUS and Germany.